USGS
science for a changing world

Geographic Analysis and Monitoring Program

In 1913, Miami, Florida, was a small settlement along the banks of the Miami River. Eighty-four years later, the city and its surrounding landscape had been utterly transformed. Buildings stood where woodlands once grew. Networks of streets and highways had replaced wetlands. And the city's population had burgeoned from a few thousand to some 350,000. Today, Miami and its neighboring municipalities comprise the Nation's eleventh largest metropolitan area.

How significant are such changes to the landscape? What impact do they have on natural ecosystems, resources, climate, and human health? How do changes in one location affect other parts of a region, an entire country, or the rest of the world? What can we learn from past land surface changes that will enable us to better predict and handle changes in the future?

The Geographic Analysis and Monitoring (GAM) Program is designed to answer these and other vital questions about land surface change.

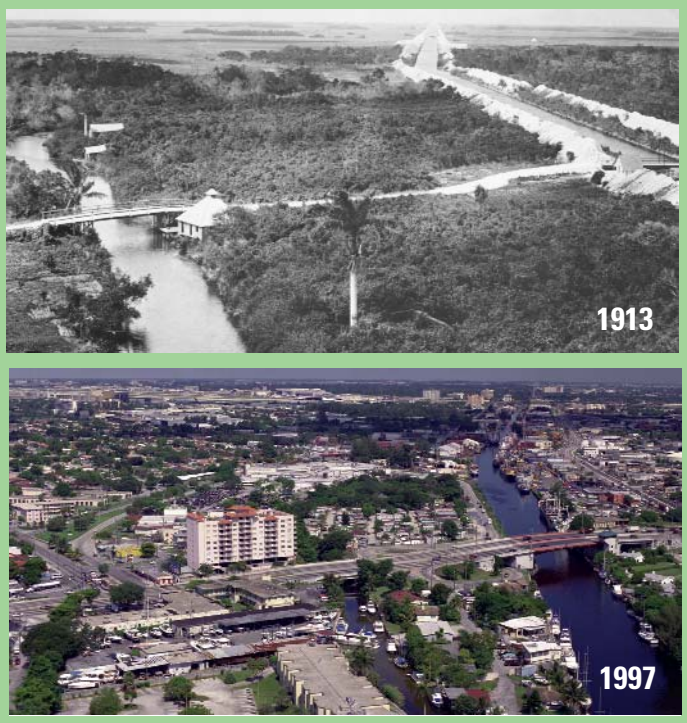

Figure 1. *These two photographs of the same location in Miami, taken in 1913 and 1997, exemplify how dramatically urban expansion can alter the landscape, ecosystems, and the human environment over time. (photos courtesy of: Historical Museum of Southern Florida, top; South Florida Water Management District, bottom)*

What is GAM?

The Geographic Analysis and Monitoring Program is a major focus of the U.S. Geological Survey (USGS), the scientific research agency of the Department of the Interior. Utilizing innovative approaches to geographic analysis and monitoring, the GAM Program provides national and global perspectives on land surface change. In so doing, it yields insights into many urgent environmental, natural resource, and economic issues. GAM also provides essential data about the consequences of change needed by decision makers in land use planning, management, and resource conservation.

A Changing Planet

Earth's surface is changing rapidly. Some changes have natural causes, such as earthquakes, floods, or drought. Other changes, such as urban expansion, deforestation, and agriculture, are human-induced.

Whatever their cause, land surface changes can have profound environmental and economic impacts. They can affect human health and the health of ecosystems, influence vulnerability to floods and fires, interfere with biogeochemical cycles, threaten biodiversity, alter water and energy budgets, and affect air quality. Cumulatively, changes at the local level have the potential to adversely affect global climate and threaten the sustainability of natural systems worldwide.

Focus of GAM Research

The GAM Program focuses on providing the comprehensive information needed to understand the rates, causes, and consequences of land surface change due to both natural and human-induced processes. The Program's research activities address four fundamental questions: What kinds of changes are occurring and why? What are the impacts of these changes? How do these impacts, in turn, affect the land surface? And how best can GAM Program findings be utilized?

Program Goals

To answer these important questions, the GAM Program has several key research goals:

- Analyze, model, and predict the consequences of land surface change on ecosystems at regional, national, and global scales.

- Determine how changes in land use and land cover impact Earth's climate and its biochemical and geochemical processes.
- Analyze land use practices to better understand how they contribute to land surface change.
- Investigate how changes in land use and land cover affect the spread of infectious diseases.
- Develop more versatile techniques to monitor land surface change and ecosystem structure and function.
- Better communicate research results and assist decision makers in developing strategies for enhancing ecosystem sustainability.

Achieving these goals requires innovative investigations into many aspects of land surface change. Research projects being carried out under the GAM Program take an integrated approach, capitalizing on biologic, hydrologic, and geologic resources to analyze change and its impacts both spatially (by location) and temporally (over time).

Working throughout the United States and at selected overseas sites, GAM Program researchers are studying land use and land cover patterns, structure and function of ecosystems, sustainability of natural resources, biogeochemistry, natural hazards, and the effects of change on human health and lifestyle. They are quantifying rates of change, identifying key forces that drive it, and forecasting future trends. In their research, they employ data from *The National Map*, satellite imagery, and other remotely sensed data, together with computer modeling and field observations.

A Sampling of GAM Projects

GAM research projects address topics ranging from the effects of land use change on the Chesapeake Bay ecosystem to wildland fires and the global carbon cycle. A few GAM Program projects are highlighted below. For a complete project listing, visit: gam.usgs.gov/gam-currentstudies.shtml.

Land Cover Trends

The Land Cover Trends project is a joint effort between the U.S. Geological Survey and the U.S. Environmental Protection Agency to study land cover change in the conterminous United States from 1972 to 2000. The project divides the U.S. into 84 "ecoregions." Each ecoregion is a geographically distinct assemblage of environmental conditions, soil type, terrain, natural communities of living things, and human activities.

Historical Landsat satellite images and aerial photographs are used to determine the land cover in each ecoregion for five periods, typically 1973, 1980, 1986, 1992, and 2000. These data are then combined with on-site observations to determine trends in how, and to what degree, each ecoregion has changed over time as well as the primary driving forces behind the changes (Figure 2). Results from the Land Cover Trends project will reveal a detailed story of land cover change in the lower 48 States over the past three decades.

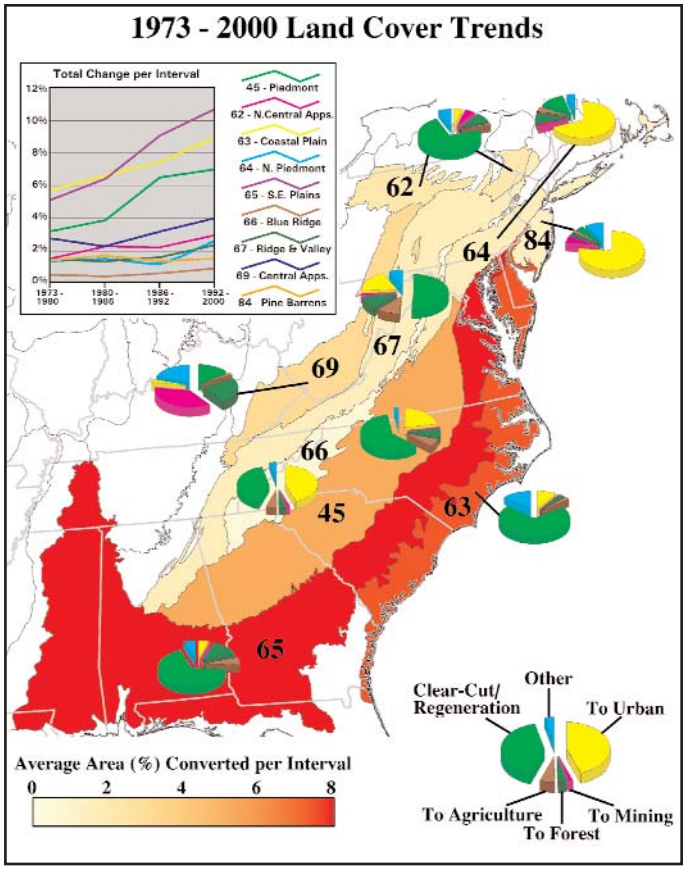

Figure 2. *In this figure, ecoregion color (see scale, lower left) represents the average amount of land cover change per analysis period (1973-80, 80-86, 86-92, and 92-2000). Pie charts depict the major types of transformations within each ecoregion. The inset graph (top left) shows overall rates of change for each analysis period.*

Geographic Analysis of Disease

Health problems caused by infectious diseases are a growing concern worldwide. Certain diseases are shared by people and wildlife. Invertebrates such as mosquitoes can be carriers of infection between the two. Since outbreaks of viruses and other disease-causing agents are often evident in wildlife populations before people are affected, understanding environmental health is essential to protecting human health (Figure 3).

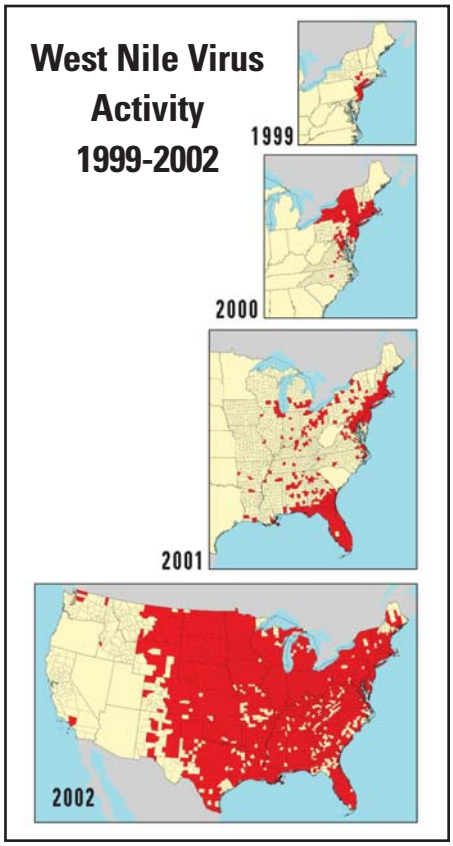

Figure 3. *In the United States, the first cases of West Nile virus, which is transmitted by mosquitoes to birds and certain mammals, including people, occurred in New England. GAM researchers are employing geographic analysis and monitoring techniques to better understand how geography and other factors affect the spread of the virus. This map shows in red all counties in the United States in which West Nile virus was discovered to be present (in humans, horses, wild birds, chickens, or mosquitoes) in 1999, 2000, 2001, and most of 2002.*

The recent spread of West Nile virus across the United States highlights the importance of understanding the complex geographies of such diseases. As part of the GAM Program, researchers from the USGS and the Centers for Disease Control and Prevention (CDC) are working collaboratively to monitor and model environmental changes, such as altered land use patterns and urban growth, which increase the rate of human exposure to West Nile virus. They are also developing forecasting techniques to help predict the spread of the disease.

Post-Fire Mapping and Analysis

Wildland fires can seriously disrupt ecosystems and nearby urban areas. Assessing fire hazards and identifying ways to reduce them are key aspects of the Nation's fire management policy. Researchers with the GAM Program's Post-Fire Mapping and Analysis project, working with the National Park Service and the USGS Biological Resources Division, are using Landsat satellite data to create burn severity maps (Figure 4). Burn severity is an overall index of fire effects and ecosystem response. These maps are used by land managers to assess the impact of major fires, monitor ecosystem restoration, and identify opportunities for fire-risk reduction.

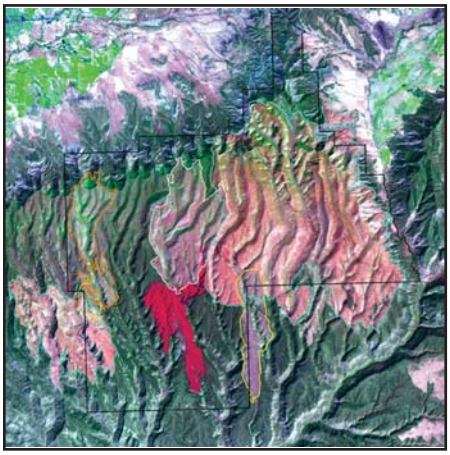

Figure 4. *This burn severity map of Mesa Verde National Park in southwestern Colorado shows several fire scars (in various shades of red) from major wildland fires that occurred on this juniper-and-sagebrush landscape between the 1950s and the present. Bright green indicates healthy vegetation.*

Urban Dynamics

Metropolitan areas in the United States are growing at unprecedented rates, creating extensive urban landscapes where farmland, wetlands, forests, and other natural ecosystems once existed. GAM's Urban Dynamics research project analyzes landscape transformations resulting from the growth of metropolitan areas over time (Figure 5).

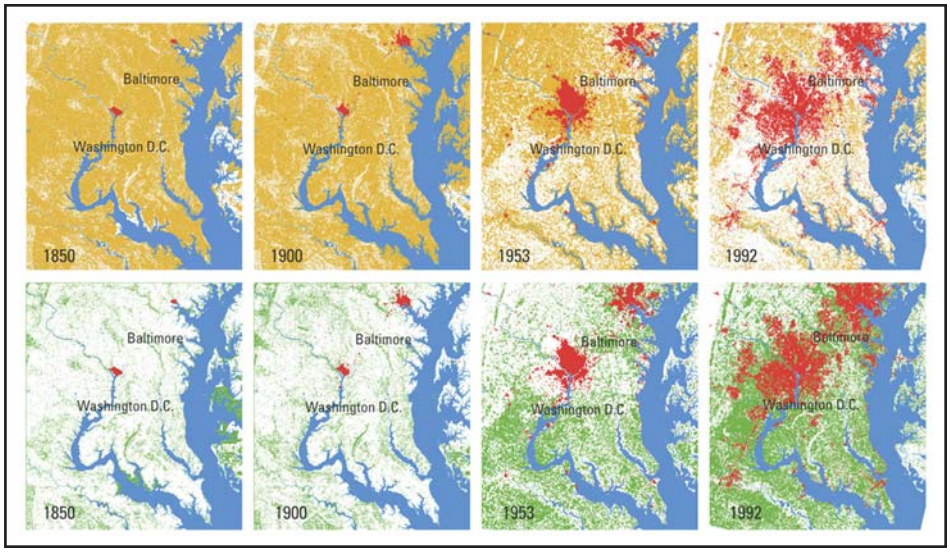

Figure 5. *This series of maps compares changes in urban (red), agricultural (gold), and forested (green) lands in the Patuxent River watershed near Washington, D.C., over the past 140 years. Since about 1900, the amount of agricultural land has declined as urban areas and forested lands have increased.*

Using historical maps, aerial photographs, and Landsat satellite data, researchers assemble retrospective urban land use databases to reflect several decades of change. These are then used to analyze the impact of urbanization on the landscape, and model future urban growth under alternative scenarios. Armed with a clear understanding of past change and impacts, communities and regions are better equipped to plan and prepare for environmentally sustainable future growth.

Early Warning and Environmental Monitoring

The U.S. Government extends economic, development, and humanitarian assistance to friends and allies in the developing world. Many of these countries are threatened with resource depletion, land degradation, floods, droughts, and other natural hazards. The Early Warning and Environmental Monitoring project, through its Famine Early Warning System Network (FEWS NET) activity, strives to reduce the incidence of drought-induced famine in 17 African countries by 1) providing timely and accurate information regarding potential famine conditions (Figure 6), and 2)

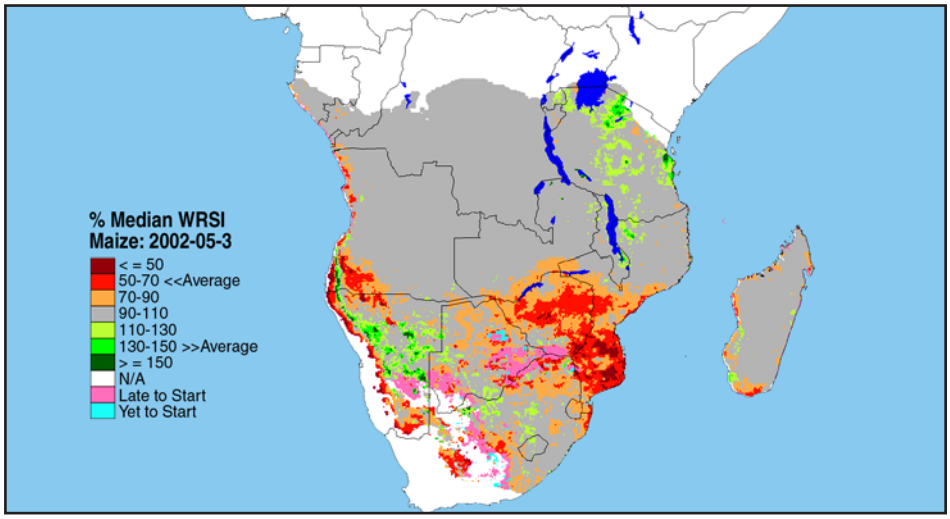

Figure 6. *Crop water balance calculations, derived from remotely sensed data, are used to map the extent and severity of drought in Africa. This type of geographic analysis guides ground data collection to determine the number of people affected and the scope of the required response by the international community. This image shows Southern Africa in 2002, where 1.2 million metric tons of food aid are needed by over 12 million people in 6 countries. (Red, pink, and white areas are the most seriously affected.)*

helping to establish more effective food security and response planning networks.

With support from the U.S. Agency for International Development (USAID), GAM Program researchers assist FEWS NET by providing access to satellite data and other remote sensing and geographic information system (GIS) technologies in order to identify threats to food security from drought and flood hazards.

Sustainable Tree Crops

The Sustainable Tree Crops project focuses on enhancing sustainable development among small landholders in Africa, Latin America, and the Caribbean. GAM Program researchers work with local cooperators to develop GIS-based systems that document production methods for tree crops such as coffee, cacao, and cashews, provide data for improving crop management strategies, and promote environmentally sound agricultural practices. Distributors and consumers can access these databases via the Internet. The project emphasizes increased productivity, enhanced market efficiency, and improved socio-economic return for farmers, while at the same time promoting biodiversity, resource conservation, and restoration of degraded land (Figure 7).

Communication of Risk

Translating scientific data into information that is accessible, easily understood, and socially relevant is a challenge faced by many research agencies. The GAM Program's Communication of Risk project addresses this challenge. The project is working to develop innovative methods for better communicating USGS scientific research results—including spatially oriented land use, land cover, and earth science data—to land managers and other decision makers who are wrestling with complex economic, social, and environmental issues. Many of these issues stem from the need to mitigate risks posed by natural or human-made hazards such as earthquakes, floods, and pollution.

An initial outcome of the project is the Land Use Portfolio Model (LUPM). This technological tool combines hazard information with economic theory data and can help decision makers weigh the economic and environmental pros and cons of various risk-reduction strategies (Figure 8). To put the LUPM into practice, researchers are developing customized, interactive GIS-based extensions that users can employ to quickly compare various approaches to risk reduction to determine which options best suit the needs of a particular community or region.

Program Outcomes

Although the GAM Program is new, it builds upon the long tradition of land cover mapping activities within the USGS. By conducting assessments to understand the rates, causes, and consequences of land surface change, the Program will provide information critical to addressing National agenda issues and understanding global change, and in support of foreign policy initiatives, especially in developing countries.

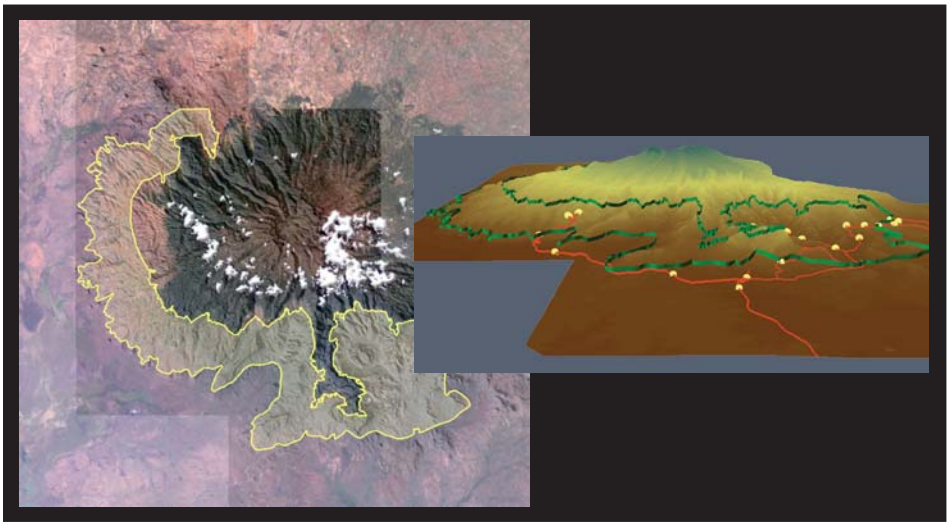

Figure 7. *By combining satellite imagery, GPS coordinates, and a digital elevation model, researchers with the USAID-funded Sustainable Tree Crops project in Africa created these images showing the coffee production area (outlined in yellow, left, and green, right) on the slopes of Mt. Elgon in Uganda. Mt. Elgon National Park lies directly above this area. Shade-grown coffee farms can act as ecological buffer zones around national parks and other protected lands.*

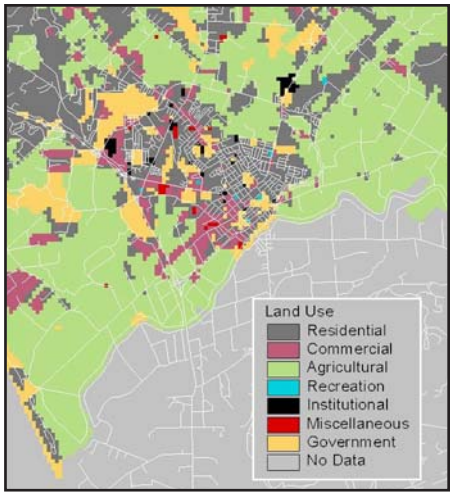

Figure 8. *Communication of Risk project researchers combine land use data, such as those used to create this image of Watsonville, California, with hazard information, economic theory, and other data sets to compare different approaches to risk reduction in communities.*

Cooperators and Customers

The GAM Program collaborates with and provides information to a broad assortment of Federal, State, and public organizations that make land management decisions and shape policy. Primary partners are Department of Interior bureaus and regulatory agencies working with the USGS, and other government agencies including the U.S. Environmental Protection Agency, U.S. Forest Service, USAID, and National Weather Service.

The GAM Program maintains and strengthens existing ties to academic institutions through grants, cooperative projects, on-site faculty, and graduate students. GAM is also aligned with the research objectives of the U.S. Climate Change Science program and is an active participant in international global science initiatives.

For More Information

For more information on the Geographic Analysis and Monitoring Program, please contact:

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